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Project: D0 High Voltage System Support
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Subject: Trip Chains between modules and racks

Introduction

The D0 high voltage modules (BiRa model 4477) provide Trip Chain input/output connectors allowing for the formation of “trip groups” across modules, backplanes and racks. This note details the allowable configurations and the limits of the chaining circuitry.

Topology

Each D0 high voltage module contains up to eight “pods”. Error conditions such as out-of-tolerance voltage or current can cause a trip condition that causes that particular pod to cease driving high voltage. A TTL digital signal is produced by each pod to indicate this condition that is buffered by the high voltage module and presented to the system’s special J2 Backplane. An open-collector TTL buffer is used, the 74ALS641, as shown in Figure 1. Individual pod trip outputs are driven by EP610 programmable logic parts, one per HV pod.

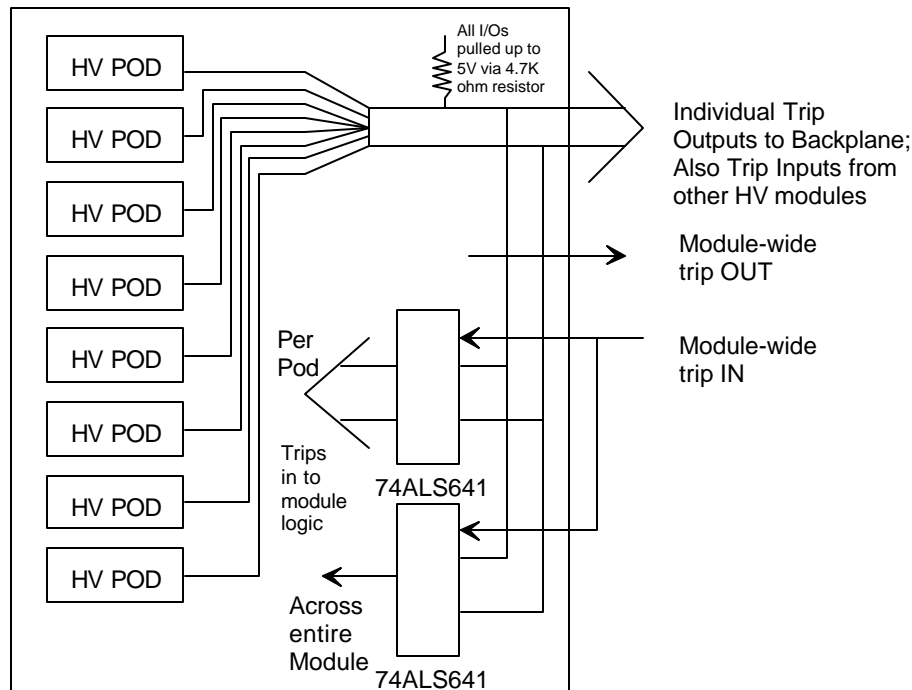


Figure 1

This open collector topology allows multiple individual trip I/O pins to be tied together into a “trip group”. The group may span multiple modules within the same crate or even include modules in different crates. If any HV pod within the group trips, all other HV pods within the same group will be tripped in response.

Circuit Limitations

The size of a trip group may not grow without bound. With each high voltage channel that is added to a trip group, the amount of current that must be sunk by the tripped channel increases due to parallel pullup resistors and parallel IC loads. Examination of the 74ALS641 and EP610 data sheets elicits the following chip parameters:

- $I_{OL,MAX} = 24 \text{ mA}$ (maximum output current that can be sunk)
- $I_{IL,MAX} = 0.1 \text{ mA}$ (maximum bias current of an input pin)
- $V_{IL,MAX} = 0.8 \text{ V}$

The schematics provided by BiRa indicate that the nominal V_{CC} of the HV module is 5.0V and the pullup resistor for each trip output is nominally 4.7K ohms. A moments calculation then derives the size of the maximal trip group. Using

- $V_{CC} = 5.5 \text{ V}$ (10% over)
- $R_{PULLUP} = 4230 \text{ ohms}$ (4700 – 10% tolerance)
- $V_{IL,MAX} = 0.4 \text{ V}$ (allowing 0.4V ground difference between crates)

$$I_{LOAD} = \frac{(5.5 - 0.4)}{4230} + 0.1 \text{ mA} = 1.206 \text{ mA}$$

Dividing $I_{OL,MAX}$ by 1.206mA gives a possible drive of 18 loads that may be in a group, but this doesn't take into account losses from the trip cables themselves. A more conservative number is 16.

Forming uni-directional trip groups

By use of a diode the open-collector output of one channel or module may be used to trip another channel or group of channels, but the 'driven' channels cannot trip the 'driving' channel. Use of the diode also affects the number of channels that may be driven due to the voltage drop of the diode. The $V_{IL,MAX}$ parameter is reduced to zero to compensate for the voltage drop across the diode. Dividing I_{LOAD} by $I_{OL,MAX}$ then yields a result of $(24 / 1.4)$ or 17, resulting in new, lower limit of 15 loads. A sketch showing how the uni-directional trip is implemented is given in Figure 2. The module on the left can trip both modules on the right. Either module on the right can trip the other module on the right. Neither module on the right can trip the module on the left. If one wished an arrangement where the module on the left could trip both modules on the right but the modules on the right could not trip each other, then two wires, each with their own diode, are required to be run in parallel.

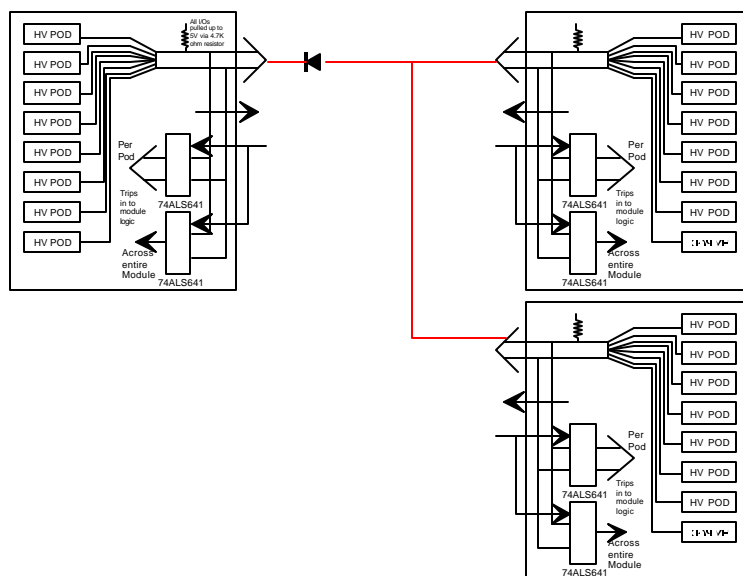


Figure 2

Conclusion

Based upon the datasheet and schematic information, using trip groups no larger than 15 pods should work in any configuration. Unidirectional trip groups are possible through the use of diodes. The diode reduces the allowable size of trip groups from 16 to 15 modules.